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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON D C 20546

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**FOR RELEASE:** IMMEDIATE
April 17, 1967

RELEASE NO: 67-93

**PROJECT:** SAN MARCO-B

(To be launched no earlier than April 22, 1967)

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4/15/67

NEWS NASA
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# SEA PLATFORM
# IS LAUNCH PAD
# FOR SAN MARCO

An Italian satellite, the first of any nation to be launched into orbit from a platform at sea, is scheduled for launching from Formosa Bay off the coast of Kenya, Africa, no earlier than April 22.

The satellite, San Marco-B, has been designed and prepared by the Italian Commission for Space Research (CRS). CRS has also been responsible for the entire launch complex. The launch vehicle itself will be a four-stage solid propellant Scout rocket furnished by the United States.

San Marco-B, like San Marco I which was launched by an Italian crew from the National Aeronautics and Space Administration's Wallops Station, Va., in December 1964, is a cooperative CRS-NASA project under an agreement concluded May 31, 1962 (text attached).

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Primary objective of the project is to obtain continuous equatorial air density measurements at satellite height by monitoring the drag forces on a spacecraft. These measurements are of particular scientific interest because two currently-used techniques give contradictory results. A second experiment will investigate ionospheric characteristics causing interference with long-range radio transmissions.

The launching platform which looks much like an off-shore oil drilling platform, is also called San Marco. It is stationed three miles off the coast of Kenya about $2\frac{1}{2}$ degrees south of the equator. A smaller platform, the Santa Rita, located about 500 yards from the San Marco platform, contains the control and operations center, range equipment and test rooms. The two platforms are connected by submarine control and power cables.

The 285-pound satellite will be launched into an orbit inclined about $2\frac{1}{2}$ degrees to the equator, with a perigee of about 135 miles (214 kilometers), an apogee of about 420 miles (677 kilometers) and a period of 94 minutes.

The measurement of air drag forces is accomplished by a payload configuration consisting fundamentally of two concentric structures--a heavy spherical structure contained in a much lighter spherical outer shell. The two spheres are linked by non-rigid connections.

-more-

When the satellite moves toward the inner part of its orbit, the light outer shell encounters the thin upper atmosphere and is retarded by this drag to a slight degree. The heavy inner core, however, continues traveling unaffected except for the forces transmitted by the flexible connections. The result is that the distances change between the outer shell and the "floating" inner core.

Equivalent position changes take place in three flexible arms that connect the core and the shell. The precise degree of movement, reflecting atmospheric drag--the air density--is measured by strain gauges and transmitted to ground stations by radio.

The second experiment, with instruments attached to the inner core, will investigate ionospheric irregularities and electron content.

Both experiments will operate at maximum advantage as a result of the equatorial orbit, which eliminates any effects of latitude differences on the experiment. Selection of an equatorial orbit also makes possible reception of data from the area of coincidences of the geographic equator and the magnetic equator.

Under the 1962 agreement, NASA is providing the launch vehicles, use of its facilities and training for Italian personnel.

The Italian group is responsible for design, fabrication and testing of all payloads and experiments as well as the launching of the Scout. The Italian team established the range, including the mobile platforms, and, with some support from NASA, tracking and data acquisition facilities necessary to the project.

No exchange of funds between the two countries is involved. Scientific data resulting from the program will be made available to the world scientific community.

About 75 members of the Italian San Marco project team have been in training at intervals for the past few years at Wallops Station, Va., and other NASA facilities as well as at Ling-Temco-Vought (LTV), Dallas, Tex., the Scout prime contractor.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS)

## SCIENTIFIC PURPOSE

The scientific purpose of the San Marco Project is to perform a series of experiments of common interest to NASA and the Italian Commission for Space Research. Primary purpose of the experiments is measurement of local density in the upper atmosphere in the equatorial region.

### San Marco I

San Marco I, launched Dec. 15, 1964, provided data which:

1. Confirmed the usefulness and reliability of the drag balance device for accurate determination of air density values.

2. Demonstrated that the drag balance could be used to determine the attitude of the satellite and to obtain a better understanding of the drag coefficient and its variations with time.

3. Are of scientific interest when compared with other data available on air density.

## EXPERIMENTS

The purpose of the experiments aboard the San Marco-B spacecraft is to investigate the Earth's atmosphere characteristics. The specific areas to be investigated are:

-- The atmospheric density in the altitude range between approximately 135 and 217 miles (214 and 350 kilometers).

-- The electron content between the spacecraft and ground, the local electron density irregularities, and the guided propagation phenomena (ducting) particularly around the geomagnetic equator.

### Air Density

The purpose of this experiment is to perform a continuous and direct measurement of the atmospheric drag and, therefore, of the atmospheric density in a range of altitudes from perigee to approximately 350 kilometers. The experiment will permit measurement of short-period variations such as the daily density variations and particularly those linked to magnetic storms.

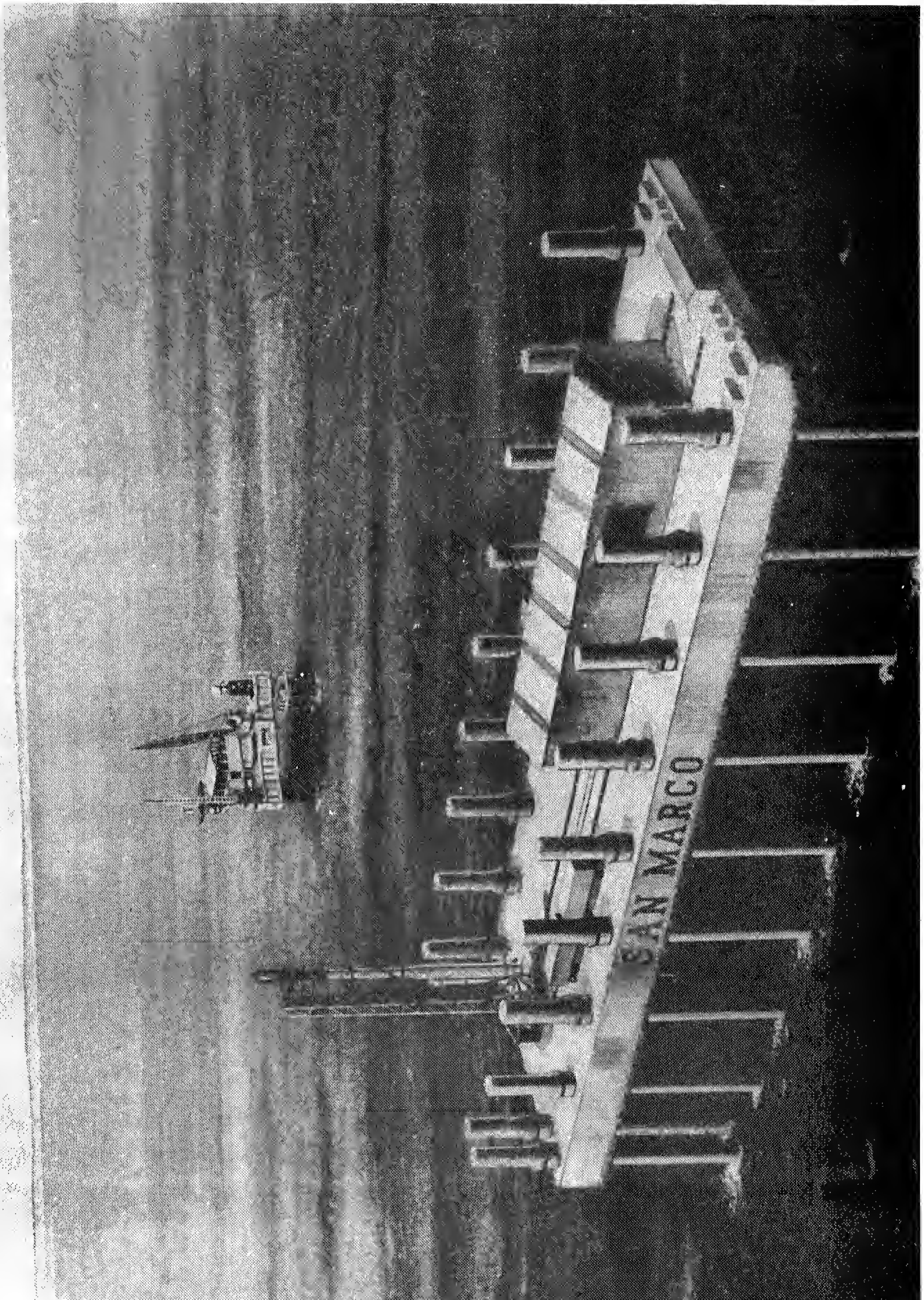
The continuous measurement should assist in determining the molecular temperature of the atmosphere and, with some assumptions, the mean molecular weight. The spin rate of the spacecraft must be minimized because of the sensitivity of the air density balance. Therefore, the spacecraft is despun to less than 6 rpm shortly before spacecraft separation. The spacecraft spin axis has a random orientation.

## Ionosphere Experiment

The purpose of this experiment is to measure the total electron content between the spacecraft and ground, study the ionospheric irregularities responsible for scintillation in the equatorial zone, and investigate the ionospheric guided propagation (ducting) phenomena. Because of the low-inclination orbit of the San Marco-B, particular propagation conditions may arise that allow an easy evaluation of the total electron number by measuring the spacecraft signal vector rotation angle.

The investigation of the total electron content and its variation with time and longitude is of particular interest because of the equatorial ionospheric anomalies. Irregularities in electron density distribution will be detected through amplitude scintillation of the received signal and by direct measurement of the fluctuations of the antenna impedance telemetered to the ground.

The ducted phenomena will occur when the spacecraft passes immediately below layers of high electron density. The spacecraft signals, which pass between the ionized layers at a low angle of incidence, can experience the guided propagation phenomena which permit signal transmission for great distances. The possibility of receiving a spacecraft signal guided via an ionospheric duct at a ground station is related to the existence of a gate through which the signal can reach the ground. The gate is primarily caused by lack of uniformity in the ionosphere.

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## LAUNCH PLATFORM

Launching of San Marco-B will take place from a mobile base consisting of two floating platforms which are fixed to the sea bottom by movable legs. Use of this type of launch platform, never previously employed, has the following advantages:

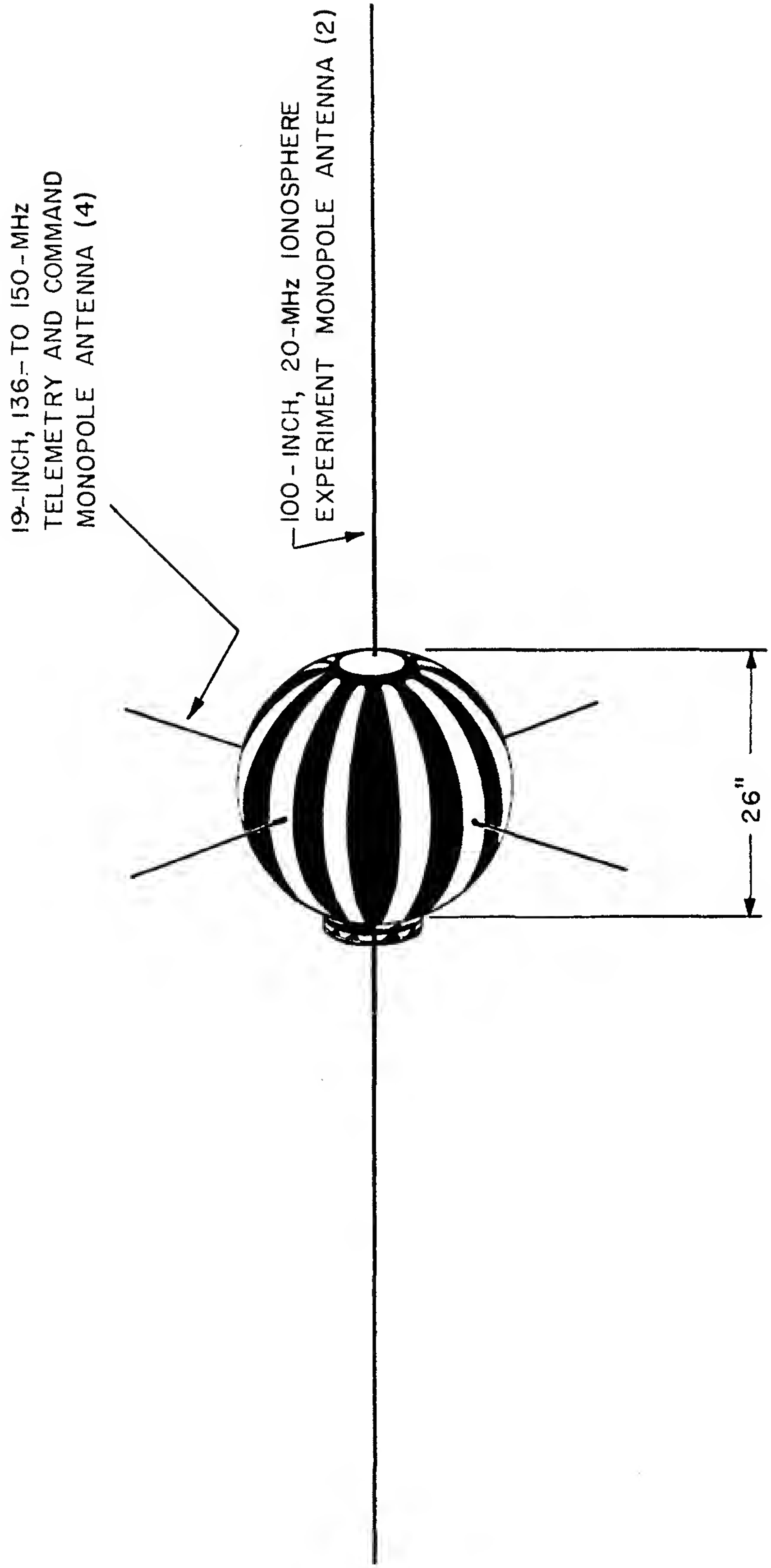
1. Makes possible launchings by a country whose geographic location does not permit launchings from within its own borders,

2. Permits launchings from a wide variety of locations.

The San Marco rocket launching platform was originally part of a U.S. mobile facility. It has 20 steel legs firmly embedded in the sandy seabed at latitude 2° - 56' - 40" South, longitude 40° - 12' - 47" East--ideal for equatorial space launchings. The 120-foot shed which houses the Scout vehicle prior to launch is air conditioned for environmental control. A large pit on the launch platform, open to the sea, will absorb the rocket exhaust of the Scout first-stage motor.

The Santa Rita platform, a modified oil drilling platform built by the Italian firm Nuovo Pignone, contains the nerve center of the project, the control room, and houses the tracking and instrumentation required to launch and track the Scout.

There are 23 cables linking the San Marco launch complex with its sister platform. Some idea of the complexity of the operation can be gained from the fact there are more than 3,000 connections of various kinds linking the two platforms. Independent generators at the two locations produce electricity at two voltages to meet the requirements of the scientific equipment and the housing and other facilities.




San Marco spacecraft configuration

## SPACECRAFT

The San Marco is a 26-inch-diameter sphere with four 19-inch monopole antennas for telemetry and command and two retractable 100-inch monopole antennas for the ionospheric experiment. Six solar cells, mounted on the spacecraft shell, provide a rough indication of the satellite attitude.

The structure of the spacecraft forms an integral part of the air density experiment. The experiment configuration consists of a light external shell connected through the elastic elements of the air density measuring balance to the heavier internal structure of the spacecraft. The internal structure consists of a cylindrical center post and a central drum. The longitudinal stresses are supported primarily by the center post. A system of diagonal struts connects the periphery of the drum to the poles of the cylinder to increase the spacecraft rigidity.

The power supply, consisting of four battery packages, is stored inside the drum. The spacecraft electronic instrumentation is mounted on the upper and lower sides of the drum. The air density balance is housed in the center of the cylindrical post, in a position of symmetry with respect to the inner and outer structures. The spacecraft main body is connected to the launch vehicle during the launch phase by means of an adapter ring joined to the cylindrical post by eight short ribs. The main body of the spacecraft is constructed of aluminum alloys.

The outer shell of the spacecraft and the arms which connect the shell to the air density balance constitute the movable structure of the spacecraft. The shell is a thin-walled sphere formed from spun aluminum. The tubular arms are connected at the poles of the shell and go through the center post to the balance element. A series of windows is provided on the shell for the umbilical and continuity plugs, the antennas, and the eight columns of the adapter ring.

A pneumatic caging system protects the air density balance mechanism from excessive loads during launch. The system connects the outer shell directly to the inner structure, thereby by-passing the balance mechanism.

In addition, the elements of the balance are separately caged by actuators operated by the pneumatic system. At launch the pneumatic system is under pressure. The pressure is released at spacecraft separation, thereby uncaging the balance mechanism.

## Instrumentation

The spacecraft electronic instrumentation has been divided into the following seven main systems:

- Air density experiment electronics (drag balance)
- Ionospheric experiment electronics
- Programmer and safety timer
- Power supply
- Telemetry system
- Command system
- Antenna system

### Air Density Experiment Electronics

The air density experiment performs a continuous measurement of the forces (aerodynamic pressure) acting on the external surface of the spacecraft. The main instrumentation of the experiment is the air density balance, an elastic system that connects the external shell to the inner structure of the spacecraft. Three orthogonal elastic elements connected in series are used to separate the three components of the total force along the principal axes of the spacecraft. The displacements of the elastic system are amplified and demodulated to obtain dc signals proportional to the force components.

The sensitivity of the balance system can be changed from 2.5 gram full-scale to 1 gram full-scale by ground command. In the 2.5-gram full-scale mode, an automatic change of gain of the amplifier (1 to 10 ratio) is provided to obtain an extension of the measured forces up to 25 grams. Zero shift of the balance (within $\pm$ 80% of full-scale) can be corrected by ground command.

The zero shift correction circuit consists of three dc-motor-driven potentiometers, one for each axis. Correction signals obtained from the potentiometers are added to the outputs of the balance to compensate for shifts in the balance outputs. Commands are provided to produce clockwise or counterclockwise rotation of the motors. The length of the second execute tone of these commands can control the magnitude of the shift correction.

An in-flight calibration signal is included with the air density experiment. The signal consists of three levels of $\frac{1}{2}$-second duration each and is superimposed every 32 seconds on each of the three force channels.

Ionospheric Experiment Electronics

The ionospheric experiment consists of an HF transmitter operating at 20.005 MHz. The transmitter carrier is frequency-shift-keyed (FSK) for recognition of the radiated signal. The transmitter feeds two monopoles of an extensible dipole antenna through a matching network. The antenna, normally retracted, is extended when the ionospheric experiment is turned on by ground command. The normal characteristics of the transmitter are:

| | |
|---|---|
| Frequency | 20.005 MHz |
| Output power | 600 mw |
| FSK frequency shift | -100 Hz to 20.0049 MHz |
| Amplitude modulation | 0.1 db |

Programmer and Safety Timer

The programmer, which is activated by ground command, is used to control the air density experiment and/or telemetry transmitter. When the proper command is received, the programmer performs the following actions:

. Turns on the air density experiment (using the drag balance electronics) and the telemetry transmitter.

. Starts an eight-minute timing cycle.

. At the end of the eight-minute timing cycle, turns off the air density experiment and telemetry transmitter.

Normally the air density experiment and telemetry transmitter will be turned off by ground command before the programmer completes its eight-minute timing cycle.

The San Marco-B has been equipped with a safety timer so that data can still be retrieved even though the command system fails. The safety timer will automatically take control of experiment selection, if no air density experiment commands are received during a six-day period.

## Power Supply

The source of power for the San Marco spacecraft is a group of mercury batteries. The individual batteries, Mallory RM-42R, 14-ampere-hour capacity, are connected in series to give the rated voltages and then in parallel to give the total rated current. The batteries are arranged in four separate packages that provide these outputs:

| | |
|---|---|
| +28 volts | -20 volts |
| +16 volts | - 6 volts |

Diodes are connected in series with the battery packages to avoid back-current.

## Telemetry System

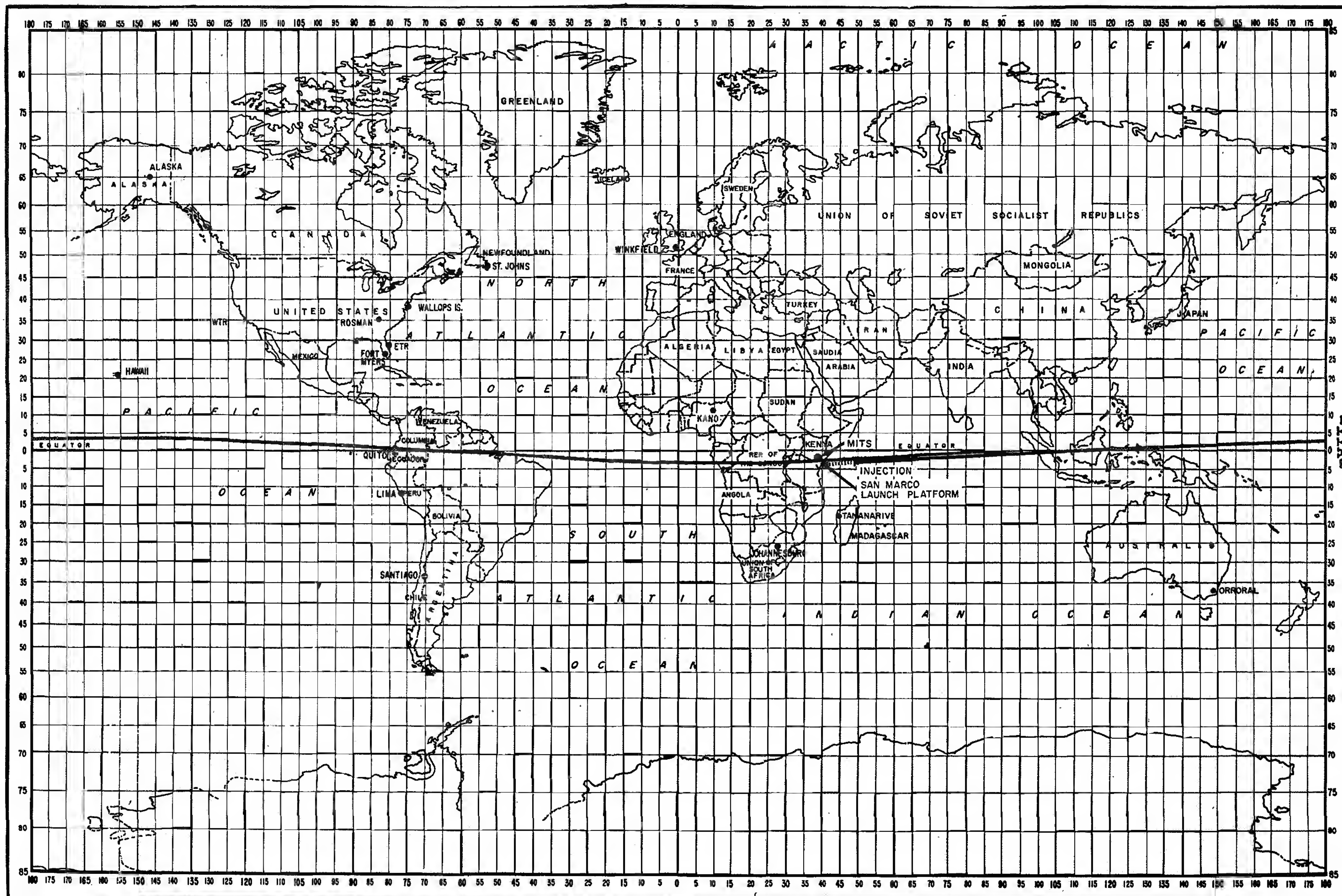
The PAM/FM/PM telemetry system consists of four continuous channels (four low-level VCO's) of FM data and one subcommutated channel (a high-level VCO) of PAM data. Three of the low-level VCO's are used to monitor the air density experiment. The fourth low-level VCO is used to monitor the variation of antenna impedance when the ionospheric experiment is on, and to monitor the spacecraft shell temperature when the experiment is off. The PAM pulse train obtained from the PAM commutator (used for housekeeping and experiment data) modulates the high-level VCO. The VCO outputs modulate a PM telemetry transmitter. Two telemetry transmitters (136.74 MHz) are provided, one for redundancy. The desired transmitter is selected by ground command.

## Command System

An audio tone command system is used aboard the San Marco spacecraft. A command frame consists of an address tone and two execute tones. The address tone is transmitted first to arm the tone decoder for a four second period during which the two execute tones are sent. The command tones are GSFC-standard except that the width of the second execute tone can be varied between 0.15 and 1.7 second for the air-density-balance shift correction. Variable width tones will be transmitted only by the Mobile Italian Telemetry System (MITS).

## Antenna Systems

The 136- to 150-MHz antenna system (used by the two telemetry transmitters on 136.74 MHz and the command receiver on 149.52 MHz) consists of four monopole antennas (19 inches long) mounted on the equatorial plane of the spacecraft in a turnstile configuration. A coaxial hybrid multiplexer network, with four terminals, is used between the antenna and the transmitter and receiver circuits.


ARCTIC OCEAN
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ECUADOR
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SANTIAGO
ARGENTINA
CHILE
ORRORAL
ATLANTIC
INDIAN OCEAN
OCEAN

## COMMAND AND DATA ACQUISITION

The Mobile Italian Telemetry Station (MITS) will have primary responsibility for commanding the San Marco-B and for acquiring telemetry data from the spacecraft. In addition, two University College of Nairobi stations (located at Dar es Salaam, Tanzania and Asmara, Ethiopia) and an Italian station in Nairobi will be responsible for acquiring ionospheric experiment data.

QUITOE, NASA's station at Quito, Ecuador, will be responsible for commanding the spacecraft and acquiring ionospheric and air density experiment data. LIMAPU, the NASA station at Lima, Peru, will be responsible for acquiring ionospheric experiment data and will act as back-up to QUITOE for commanding the spacecraft.

## TRACKING

During the launch and early-orbit phases, tracking data will be obtained by the following participating stations and tracking organizations:

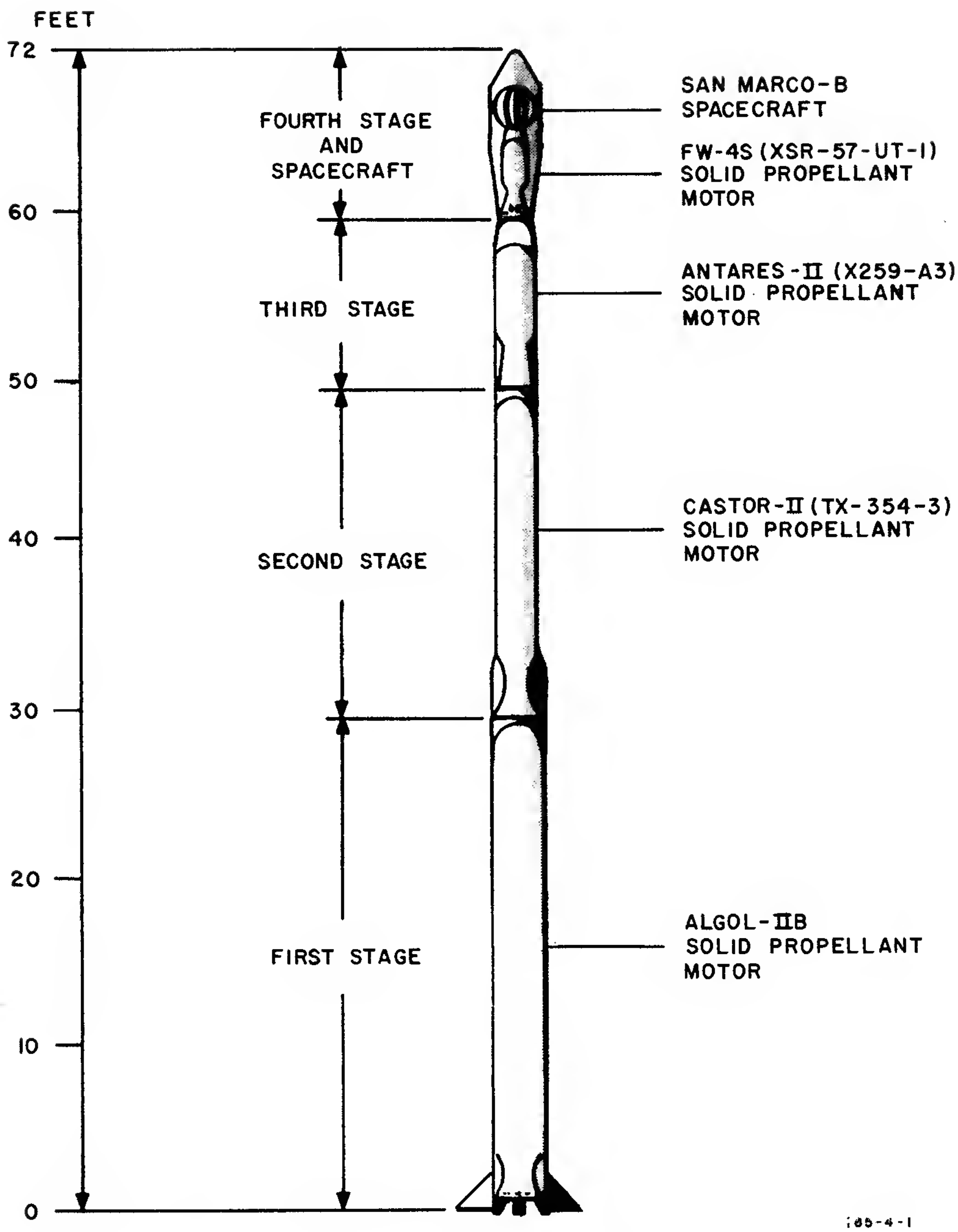
- Lima, Peru (LIMAPU)
- Quito, Ecuador (QUITOE)
- Mobile Italian Telemetry Station (MITS)
- Santa Rita Station (SRS)
- North American Air Defense Command (NORAD)
- Smithsonian Astrophysical Observatory (SAO)

During the normal phase of operation, tracking data will be obtained by the Satellite Tracking and Data Acquisition Network (STADAN). QUITOE will provide primary tracking support. LIMAPU will provide a limited amount of additional tracking support.

## SCOUT LAUNCH VEHICLE

Scout is a multi-stage launch vehicle using four solid propellant rocket motors capable of carrying payloads of varying sizes on orbital, space probe or reentry missions. Scout is 72 feet long and weighs 20 tons at liftoff.

It was developed by NASA's Langley Research Center, Hampton, Va.




Scout Launch Vehicle

The four motors are interlocked with transition sections which contain guidance, control, ignition, instrumentation systems, separation mechanisms, and spin motors. Guidance is provided by a gyro system and control is achieved by a combination of aerodynamic surfaces, jet vanes and hydrogen peroxide jets.

Scout is capable of placing approximately 310 pounds into a 300-mile circular orbit or of carrying a 100-pound scientific probe some 10,000 miles away from Earth.

Scout stages include the following motors:

| | |
|---|---|
| First Stage: | Algol IIB - 100,900 pounds thrust, burning time 80 seconds. |
| Second Stage: | Castor II - 60,760 pounds thrust, burning time 40 seconds. |
| Third Stage: | Antares II (ABL X-259) - 20,940 pounds thrust, burning time 35 seconds. |
| Fourth Stage: | Altair FW4-S - 5,750 pounds thrust, burning time 31.5 seconds. |

## SAN MARCO PERSONNEL

The project was conceived by Professor Luigi Broglio, chairman of the Italian Commission for Space Research and director of the San Marco Project. The payload was developed by Professor Broglio and his group at the Aerospace Research Center in Rome.

Professor Broglio will direct the Italian Space Commission team during the operation. Professor Michele Sirinian is Launch Crew Director and Dr. G. Ravelli is Chief Spacecraft Engineer.

Overall direction of NASA's participation is under the Office of Space Science and Applications in cooperation with the Office of International Affairs.

Langley Research Center, Hampton, Va., is responsible for technical direction of the NASA portion of the program and participated in training of the Italian launch crew.

Wallops Station trained Italian range support and operation personnel.

Goddard Space Flight Center, Greenbelt, Md., will assist in worldwide tracking and data acquisition.

NASA Program Manager is Dr. Russel K. Sherburne, OSSA, Launch Vehicles and Propulsion Programs. The Project Manager, at Langley Research Center, is Roland D. English. Louis P. Tosti is Langley Operations Director and Anthony Caporale is Goddard Project Engineer.

May 31, 1962

MEMORANDUM OF UNDERSTANDING BETWEEN THE

ITALIAN SPACE COMMISSION OF THE NATIONAL COUNCIL OF RESEARCH

AND THE

UNITED STATES NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

1. The Italian Space Commission of the National Council of Research (The Commission) and the United States National Aeronautics and Space Administration (NASA) affirm a mutual desire to conduct a series of experiments which it is hoped will culminate in the launching of a scientific satellite into an equatorial orbit. The objective is to perform measurements of atmospheric and ionospheric characteristics in a region of the earth's atmosphere not previously explored and to make the resulting scientific data freely available. This experimental program is planned to consist of three phases:

(a) First phase -- An appropriate sounding rocket will be utilized to provide a flight test of the principal elements of the scientific payload. This launching will take place from the Wallops Island Station and/or from an Italian platform of the San Marco type located near the equator.

(b) Second phase -- A prototype of the ultimate satellite payload will be placed in orbit by means of a Scout booster launched from the Wallops Island Station.

(c) Third phase -- A scientific satellite, bearing experiments as described above, will be placed in an equatorial orbit by means of a Scout booster launched from a platform of the San Marco type, located in equatorial waters.

2. The cooperating agencies shall proceed from each phase to the next upon mutual agreement that technical feasibility has been demonstrated and, in particular, that environmental requirements for the third phase of the program have been satisfied.

3. The Commission shall, in general, assume responsibility for the following:

(a) Support of Italian personnel for any training required in launching, tracking, data reduction and analysis, and other elements of the program, as mutually agreed.

(b) Design, fabrication, and testing of all payloads, including satellite engineering.

(c) Such studies and action as are required to assure a mutually acceptable environment for transport, handling, and launching of the Scout in the third phase of the program.

(d) The availability, equipping, maintenance, and operation of the "San Marco" towable platforms.

(e) The establishment of a suitable launch complex for the third phase of the program, including range safety provisions, as mutually agreed.

(f) Launching of the satellite in the third phase of the program.

(g) Data analysis in all phases of the program.

(h) Tracking and data acquisition facilities required in Phase III that are particular to Project San Marco and which are not available from NASA.

(i) Support, logistics, and all other costs peculiar to Project San Marco.

4. The NASA shall be responsible, in general, for the following:

(a) Provision of an appropriate sounding rocket and backup, as mutually agreed, for the first phase of the program.

(b) The provision of Scout boosters with backups for the second and third phases of the program.

(c) Such training of Italian personnel as may be feasible, and as may be accommodated without significant incremental expense.

(d) Technical consultation, as appropriate.

(e) Such additional ground testing of the payloads as may be required

(f) The provision of data to facilitate effective design, fabrication, and testing of the payloads.

(g) Tracking and data acquisition in the first and second phases of the program as can be accomplished by existing NASA sounding rocket and unmanned satellite tracking and data acquisition facilities.

(b) Provision of tracking and data acquisition services of the Quito, Ecuador, Minitrack Station in phase three of the program, and such additional communications support at other locations as may be feasible on a non-interference basis, subject to the concurrence, as appropriate, of any foreign governments involved. Special equipment or personnel needed in this connection will be the responsibility of The Commission.

5. No exchange of funds is contemplated between the two cooperating agencies.

6. Each agency agrees to designate a single project manager who shall be responsible for coordinating the agreed functions and responsibilities of each agency with the other. Together they will establish a joint working group with appropriate membership. Details for implementation shall be resolved on a mutual basis within this working group.

7. The scheduling of each of the three phases of the program shall be as mutually agreed.

8. All launches which are a part of this program will be in such areas as may be agreed between the two agencies which shall consult their governments, as appropriate.

9. This Memorandum of Understanding shall be subject to the concurrence of the Italian Foreign Office and the U.S. Department of State, expressed through an exchange of notes.

FOR THE COMMISSION:

/s/
Professor Luigi Broglio

FOR NASA:

/s/
Dr. H. L. Dryden

Geneva - May 31, 1962

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